The rising cost and uncertain supply of petroleum and natural gas are focusing new attention on green plants as a source of energy. But firewood, grain alcohol, and methane are only a small part of the enormous "bioresource" that surrounds the world. In the following article, two leading thinkers offer some insights into this invaluable resource.

THE RENEWABLE WAY OF LIFE

by Harlan Cleveland and Alexander King

Bioresource is a new word in our vocabulary, and for good reason. The subject is as old as hunting, fishing, and farming. But the 1970s have seen a wholesale shift in perspective that makes renewable processes suddenly seem fresh, attractive, and much more important in our immediate future than in our recent past.

The biological resources have been out there all the time, often ignored or exploited or wasted yet somehow durable in their seasonal reincarnations. There is the three-fifths of the biomass that is green plants, from the slenderest ferns to the sturdiest Sequoias; the one-fifth that is animals (including Man, the only animal that theorizes about biology or resources); and the one-fifth that is microorganisms or "microbes." But to think about all of this, in an integrated way, as a resource—that is new.


P. JOHNSON, WORLD FOOD PROGRAMME

Renewable Resources

Until quite recently, all humanity existed (and part of humanity flourished) mainly on the basis of renewable resources: agricultural products, firewood, simple devices for the generation of wind and water power. The majority of the human population still does so today. But with the impetus of the Industrial Revolution two centuries and more ago, the life-support systems began to transform the very nature of society in many parts of the world.

The new industrial societies developed by the accumulation of scientific knowledge and the spread of technological innovation. The industrial societies were fed, not as in the past essentially by the annual bounty of nature, but also by the consumption of vast amounts of nonrenewable resources—especially minerals (which yielded all the chemical elements) and fossil fuels, at first coal and then oil, which had stored up the solar energy trapped by photosynthesis over the aeons.

The use of these new (and eventually exhaustible) sources of energy influenced human development not only through industrial processes; they also modified the way bioresources were used. The traditional vegetable and animal fibers, for example, were increasingly replaced or extended by synthetics manufactured from coal and petrochemicals, altering the patterns of consumption, land use, international trade, and the distri-

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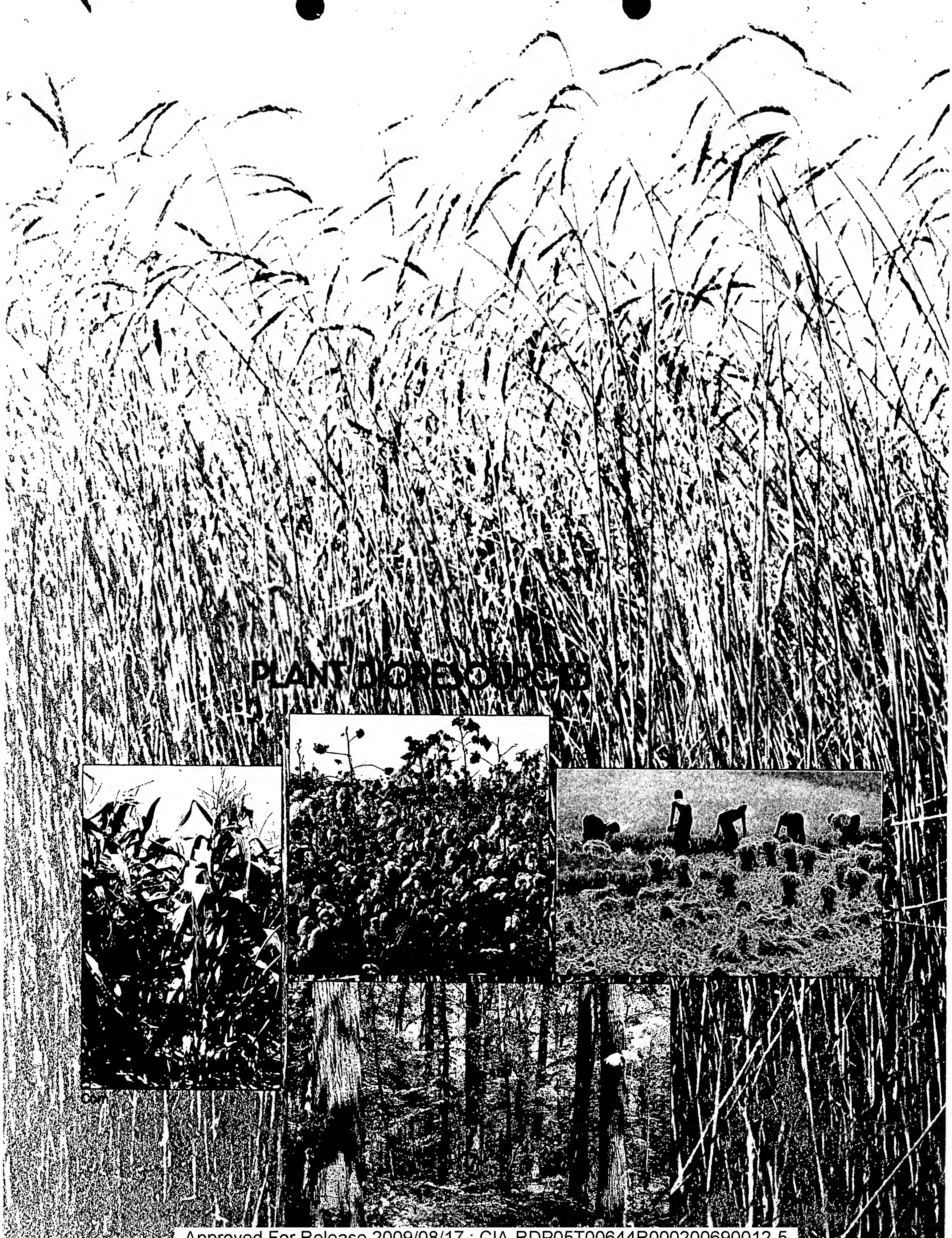

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bution of wealth. Exotic foods from around the world were transported to metropolitan centers in ships, trains, and trucks powered by fossil fuels. Even in agriculture, profound changes have resulted from the use of oil-driven tractors and other farm machinery, synthetic fertilizers, and a wide range of agricultural chemicals derived, once again, from fossil fuels; these now contribute a considerable proportion of the total energy input to food production in the most productive parts of the world. And in parallel with these developments (and made possible in part by them), expansion of world population has been extremely rapid, calling for ever greater quantities of foods and goods of all kinds, entailing the use of still further quantities of nonrenewable resources and energy.

But this pell-mell human intervention in the use of natural resources was often the opposite of beneficial. Through ignorance, thoughtlessness, and the lack of a sense of responsibility for the future, early practices—clearing land by "slash and burn," overgrazing, and damaging agricultural techniques of many kinds—led to desertification and environmental deterioration in many places. Today, with the great increase in the quantum of human activity, danger to the natural environment is more serious than ever.

During the decade of the 1970s, three new perceptions became pervasive enough to make the decade a kind of watershed—a moment of major historical change that spotlighted the bioresource potential. One new perception was the risk to the natural environment of staying in the groove of more-is-better economic growth. A second perception was the promise of bioresources for development in Asia, Africa, and Latin America. And a third was the sharper focus on the inherent characteristics of the bioresource itself—and their implications for its purposeful management.

Working with Nature

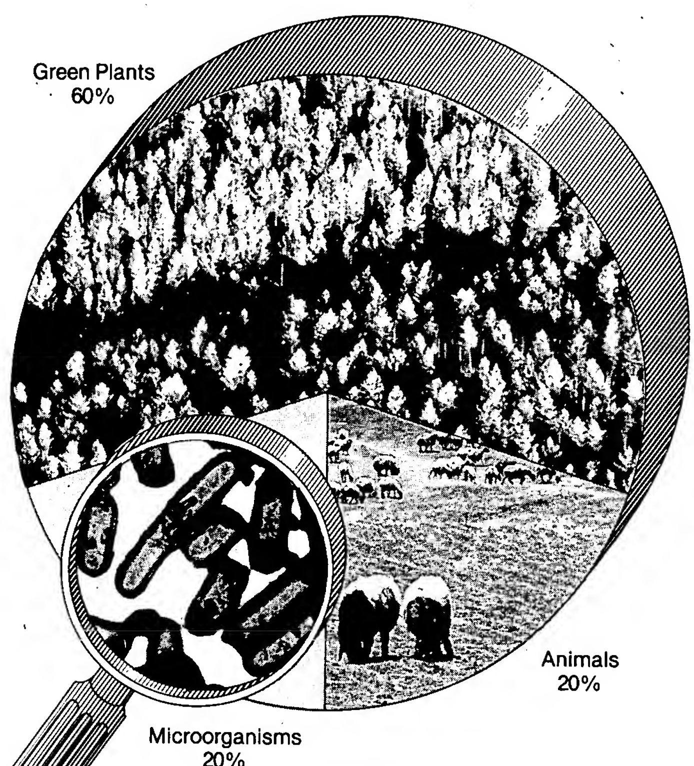
At the beginning of the 1970s, people in very large numbers in many parts of the world were questioning both the possibility and the desirability of continuing to stimulate "growth" in the directions that had become traditional—growth of the economic product, human populations, urban development, numbers of automobiles, and size of bureaucracies. The environmental risks and the threat of resource depletion were only part—an important part—of this disillusion with material growth. The doubts about growth were intensified by the petroleum crisis with its sudden and massive increase in the cost of energy, its wholesale shift in the world balance of payments and pattern of investment, and its demonstration of the vulnerability of industrialized, oil-importing countries to disruption of supplies that could threaten their economic health and styles of life. Most of the less developed countries likewise suffered from the greatly increased cost of the fuels and fertilizers they needed if their exploding populations were to be adequately fed. In both "developed" and "developing" countries the realization was coming in a rush: that oil resources could run out, and that new energy sources had to be found or invented, and developed, before the oil wells dried up.

The natural conclusion of this line of thinking was to reassess economic needs and the ways of meeting them in such a way as to reduce reliance on resources that might be near exhaustion, or at least would predictably become more and more costly during the generations to come. On the positive side, the same reasoning led naturally to working *with* nature. Maybe humanity should modify its economic practices so as to use much better the bioresources provided, and continuously regenerated, by a bountiful nature. Maybe the bioproductivity of the planet could be preserved, and indeed enhanced, to ensure this eternal renewal.

The arguments supporting such an approach seemed clear enough:

- Present and foreseeable increases in world population will call for increases in materials and energy that are unlikely to be met if present practices, policies, and life-styles persist.

THE BIORESOURCE



- Provision of basic physical needs (especially of food, clothing, shelter) of existing and foreseeable populations is politically and humanly urgent; so is a fairer chance for deprived peoples to participate in a life of modest prosperity and human dignity.
- The limits to the carrying capacity of the planet, and its toleration of human intervention and waste, are at best uncertain.
- The interest of future generations—and perhaps even of our own—requires us to reduce our reliance on nonrenewable resources such as minerals and fossil fuels, to adopt conservationist and recycling practices, and to encourage a much more effective use of the continuous inflow of solar radiation, notably the photosynthetic mechanism of the green plant.

• Humanity will need to maintain and increase the bioproductivity of the planetary soil, and mould agricultural policies and practices so as to ensure a full and regenerative use of the biomass available to man, recycling "wastes" as a new form of raw material.

Help for Third World

Multinational and bilateral aid programs have tried hard to reduce the disparities between the world's richer and poorer regions; much has been achieved, but the gaps are still wide and in some ways are still widening. Economic growth in the Third World has, in recent years, been faster on the average than that of the industrialized countries. But it started from a very low baseline; its benefits have been partly absorbed by population increase; too much of it has been used for the purchase of military equipment, and some of that represents a counter-flow of wealth from the poor to the rich; and much of the development achieved has served mainly the minority modern sectors of developing countries, and has not alleviated the misery of those who live largely outside the money economy.

"The interest of future generations—and perhaps even of our own—requires us to reduce our reliance on nonrenewable resources such as minerals and fossil fuels."

In considering how the bioresource might be used to brighten this picture, it may be helpful to recall the problems, situations, and opportunities that are generally present in, and are special to, the world's less developed regions:

• Most of them are in tropical or semitropical zones and have exceptionally reliable inputs of solar radiation.

• Many of them—though not all—are already overpopulated, are experiencing endemic unemployment and underemployment, and have abnormally high rates of current population increase—adding to demands for food, housing, water, and energy in places where hunger and poverty are already the major problems.

• They generally suffer from a scarcity of conventional energy resources—and in regions where energy resources may occur in nature, exploration for them has barely begun.

• Many less developed countries have a high rainfall, but this is often seasonal and there are many very arid lands.

• Many of the tropical soils are extremely fragile and particularly vulnerable to unwise agricultural and other practices.

• Transportation and communication are often difficult and many villages are virtually isolated.

• Poverty, disease, and malnutrition—interacting on each other—are widespread.

• In many places, agricultural residues are insufficiently and inefficiently used. The spoilage of stored foods by rodents and insects is enormous.

• In tropical lands, however, the temperature, radiation, and water supply favor a much quicker growth of the biomass than in temperate climates.

The aid programs have not, for the most part, grasped and modified the pattern of poverty they were established to tackle. For too long, they took as their starting point that growth in the gross national product, as in the industrialized countries, was the unique and inevitable path to development everywhere; that the benefits of such growth would rapidly "trickle down" to the masses of the poor; and that the technologies on which Northern prosperity is based could be quickly, easily, and relevantly transferred to quite different social and cultural environments. The first two assumptions simply proved to be wrong. The transfer of technology turned out to be extremely tricky, and its assimilation and extension fragile and uncertain, in the absence of scientific and technical competence inside each country, organically related to the educational system on the one hand and the productive sectors of agriculture and industry on the other. The aid programs learned the hard way that it was not enough for the national scientific and technological competence to develop just to serve the interests of particular individuals, groups, or even nations, if it was not part of a wider infrastructure that in some sense was serving humanity as a whole.

The promise of the bioresource is its role not as a Southern "counter culture" but as a complement to Northern technology. Each country will need, within its overall social and economic planning, to encourage a mix of different types of technology, to match its unique environment, traditions, existing level of development, and availability of relevant resources. Within this mix, bioresource development promises much—and has until now been greatly underestimated. The dangers of linear technological pathfinding have been illumined by much analysis, and illustrated by many examples, in the decade of the 1970s. The bioresource approach opens a promising array of alternative paths to world development.

Science and systems have already clothed the promise with some visible raiment. First, much empirical experience has accumulated, mainly in rural and peasant economies, about new methods of using wastes and recycling materials so as to increase the bio-yield. Examples are the widespread use of biogas generated from

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ANIMAL BIORESOURCES

USDA

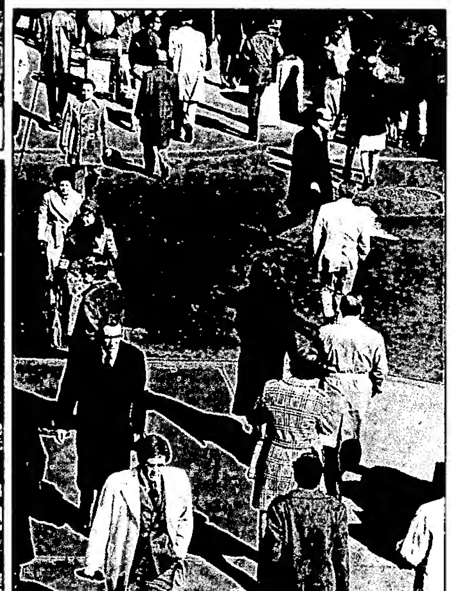
Poultry

P. JOHNSON, FAO

Sheep

Fish

ZAPATA HAYNIE CORP., HOUSTON, TEXAS



JIM KALETT/PHOTO RESEARCHERS

Man

human and animal waste now common in China and parts of Southeast Asia; inland pond fish cultivation; the use of algae as an intermediate in food production; the speeding up of plant growth (notably in rubber); and the use of quick-growing leguminous trees that can provide organic nitrogen, cattle fodder, and wood.

There is also much promise in contemporary biological research, for example in enzyme technology, genetics, and a variety of methods for the production of fixed nitrogen from plants other than the traditional legumes. Behind the many lines of applied research, there seem to be great potentials in fundamental work in molecular biology and cytology. Non-biological developments in the use of solar energy are also going forward, if somewhat slowly; they can complement the photosynthetic path in many applications.

A third line of advance comes from the application of systems science to problems of total or integrated bioresource management. The conventional approach has been to examine the possibilities of particular crops, wastes, devices, or processes in isolation from each other, with rather little attention given the management problems of resource utilization, the economic balance, or the energy flow. The systems approach tends to focus on the whole utilization of the biomass available to a particular community, including the interactions of the constituent processes, with the central objective of providing optimum outputs of food, energy, and fertilizers in an indefinitely sustainable system.

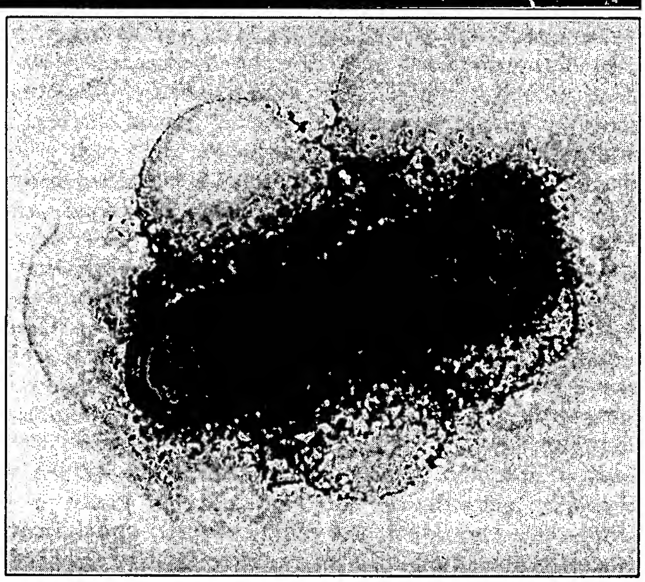
But the most important idea of all inheres not in the plants or animals or microbes, but in our own minds: the increasing and encouraging awareness of the interdependence of nations, of problems, of functions, of scientific disciplines, and of objectives.

The adjectives "holistic" and "integrative" are already bordering on the cliche, but they have a very special significance in the use and management of the bioresource. They mean, quite literally, that the problems of a nation, of a city, of a village are to be seen as interconnected and therefore to be tackled simultaneously and as a complex, not separately or sequentially. The community's future comprises economic, social, cultural, and political as well as technical facets; these cannot be dealt with by the politician alone, or by the economist, the engineer, or the scientist in isolation. When it comes to the use of resources, it is necessary to consider them all: agricultural, forest, soil, water, microorganisms, plants, animals, men and women. In a particular development scheme, only an integrated approach can make optimum use of the resources; consider food and energy requirements together; arrange for full use to be made of "wastes" and "residues"; include traditional agriculture in the community's planning; maintain soil fertility and humus content; explore food addition possibilities through fermentation and the use of plants not commonly consumed; use plant, animal, and human wastes to generate biogas for cooking, lighting, refrigeration, and distillation; develop algal and fish culture; in-

MICROORGANIC BIORESOURCES

Rainbow Fungus

WILLIAM M HARLOW



NASA

Microorganism

vent or adopt simple solar and windpower devices; and so on almost without end. An integrated plan will include a careful appreciation of the carrying capacity of the soil, so that its fertility can be maintained indefinitely, as well as of methods for augmenting it, for example by inoculation with nitrogen-fixing bacteria. It will consider the energy balance to ensure that the net energy balance is positive. And it will look to the preservation of the environment, locally and globally, in recognition of the place of man in the ecosystem, living in mandatory symbiosis with all the species of creation.

Character of the Bioresource

What are the inherent characteristics of the bioresource? How can it be perceived by man, who is part of it? What direction-signals can we discern in the bioresource for the development of purposeful technologies, the construction of an appropriate analytical system to guide policy choices, and the management of a "modernization" that makes the best and the most of the only biosphere we have?

Think first about the essence of the bioresource:

- The bioresource is *alive.*
- The bioresource is a *ubiquitous, continuous storehouse.*
- The bioresource is *resilient* (or adaptive), *versatile,* and *renewable.*
- The bioresource is *self-balancing,* full of feedback mechanisms.
- The bioresource is, however, *bulky* (there is no way to miniaturize a forest), *limited by natural cycles* (each kind of organism will grow only so fast), *variable* (each plant or microbe is different, just as people are), and *finite* (unlike another recently rediscovered resource called information).
- The bioresource is *interconnected.* (No one has said it better than Lewis Thomas, who writes of the earth as an "immense organism" where chemical signals "serve the function of global hormones, keeping balance and symmetry in the operation of various interrelated working parts, informing tissues in the vegetation of the Alps about the state of eels in the Sargasso Sea, by long interminable relays of interconnected messages between all kinds of other creatures.")
- Above all, the bioresource is *essential to human survival.*

Does this inventory of characteristics suggest the changes in concepts, assumptions, and definitions—that is, the changes in man's perceptions—that the new emphasis on the bioresource may bring about? We think it does.

Because it is alive and man is immanent in it, the bioresource requires human cooperation with the environment.

Because it is spread so widely throughout the world, the bioresource has a potential for promoting equity—for responding constructively to the "global fairness revolution." The same cannot be said of oil wells or uranium deposits. Its ubiquity also carries a potential for disaggregation and decentralization, and also perhaps a potential for reordering the urban-rural balance, which industrial civilization as we have known it has done so much to distort.

Because the bioresource is resilient and self-balancing, mistakes need not be irreversible. In managing the biomass for human purposes, we might become better able to learn from trial and error than is safe in, say, the realm of nuclear physics.

Because it is continuous, the bioresource requires us to think harder about the interest of future generations, to include sustainability in our concept of "progress."

Thinking of the bioresource as a continuous storehouse helps us see "waste" as just another form of raw material, waiting to be recycled into some productive process.

The nature of the bioresource's limits—limits to pace, to concentration, to consistency—points to ways to increase the limits, through breeding and selection and other synonyms of bioproductivity.

These conceptual changes in turn permit and even require individuals to exercise more choice. And because all choices are interconnected, in dealing with the bioresource the responsibility for outcomes is spread more widely. On a farm, productivity is a function of numberless small personal efforts, often unsupervised; these efforts cannot be optimized at the point of a gun, but only by the willingness of the farmer himself to enhance his efficiency in dozens of private and unstandardized ways.

The wider the spread of personal responsibility for outcomes, the more each participant in the management of the bioresource has to try to understand "the situation as a whole" of which his efforts can only be a very small part.

"Thinking of the bioresource as a continuous storehouse helps us to see 'waste' as just another form of raw material, waiting to be recycled."

Man's revised perceptions of the bioresource are presented here with their positive implications. But they all imply change. That means the very nature of the bioresource is a threat to existing beliefs, concepts, institutions, and power structures.

The technological choices implied by these revised perceptions leap to the eye. In the spectra of technologies by which resources are moulded to purpose, the bioresource (as compared to nonliving resources) inherently favors polyculture rather than monoculture; self-sustaining systems rather than systems requiring more and more energy input from the outside; "extensive" rather than "intensive" systems (in terms of geography, capital, or labor); economic, social, and cultural patterns that encourage independence rather than dependence (for nations, for groups, for individuals), the spreading of benefits rather than the concentration of wealth, the maximization of choice rather than the suppression of diversity, and the diffusion of individual responsibility rather than hierarchical command and control.

In a bioresource-conscious world, therefore, management will have a different "feel" to it: cooperation not coercion, horizontal not vertical structures, nobody in general charge but everybody partly in charge, multiple-objective preferred to single-purpose organizations.

More participatory decision-making implies a need for much feedback information widely available. That means more openness, less secrecy—not as an ideological preference but as a technological imperative.

In such a management environment, "planning" cannot be done with detailed blueprints. "Planning" has to be improvisation by the many on a general sense of direction, which is announced by "leaders" only after consultation with those who will have to improvise on it.

Integrative Thinking

Preparing people to participate responsibly in the kind of management appropriate to the bioresource will evidently require a wholesale review of existing educational systems. Their dedication to the separateness of specialties may have to give way to an emphasis on integrative, interdisciplinary, interprofessional, and international modes of analysis, since only these can be plugged in directly to action on an interconnected resource.

Indeed, one casualty of the new emphasis on bioresources is likely to be traditional analytical systems, especially economics; in a laudable effort to be more rigorous, economics succeeded in being too narrow. A new analytical system, one with a wider lens, is going to be needed to illuminate the technological choices and guide the pluralistic management that the new perceptions of the bioresource make both possible and necessary.

A wider frame of thinking, a wider participation in management, a wider range of technological choice—to take seriously these implications of the bioresource will certainly mean changes in our minds and our habits. But precisely because we are ourselves part of the bioresource, we may find that adjusting our minds in the directions just indicated is much more "natural" than our efforts, in this century, to adjust to space travel or telecommunications—or to urban congestion, thickening air, desertification, and the daily threat of global nuclear war.

This article is excerpted from the Introduction to *Bioresources for Development: The Renewable Way of Life*, edited by Harlan Cleveland and Alexander King with the assistance of Guy Streatfeild. The book is based on an international conference on Bio-Potentials for Development, held in Houston, Texas, November 5-11, 1978. The book is to be published this year by Pergamon Press, Elmsford, New York, and is scheduled to have about 300 pages and to cost $30.00.

The book's authors, specialists in energy and bioresources, recommend ecologically appropriate methods for the management of resources and the production of food energy. Many new lines of development are discussed, including suggestions for microbiological methods of nitrogen fixation to reduce the use of chemical fertilizers, a fish culture chain involving human effluents and algae, and a call for better understanding of photosynthesis.

The book memorializes John McHale, the futurist sociologist whose Center for Integrative Studies organized the Houston meeting. The Center now continues to operate at the State University of New York at Buffalo under the direction of Magda McHale. The new address is Center for Integrative Studies, School of Architecture and Environmental Design, State University of New York at Buffalo, 108 Hayes Hall, Buffalo, New York 14214.